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Description

[0001] The present invention relates to connectors for holding optical fibres, and in particular to a connector which allows two optical fibres to be repeatably optically coupled, decoupled and recoupled without any substantial change in optical performance.

[0002] In many optical applications, electromagnetic (e.g. laser) radiation is transmitted along optical fibres and thus must be coupled into the optical fibre at one end thereof.

[0003] One problem with coupling radiation into an optical fibre is that it is necessary to align the end of the optical fibre with a high degree of accuracy if transmission losses are to be minimised. This is because of the small size of optical fibres which means that even small errors in the positioning of the end of an optical fibre can result in large energy losses when the radiation is coupled into the optical fibre end.

[0004] This problem is exacerbated if the fibre end is contaminated with dust or dirt, as might be the case when the fibre is used in a non-clean environment. Such contamination causes large energy losses and may result in an inoperable coupling to the fibre.

[0005] To help reduce the above problem a lens is often used to focus the incident radiation beam onto the end of the optical fibre. The lens, in effect, magnifies the end of the optical fibre, thereby increasing its effective size. This reduces the sensitivity of the coupling to linear displacement between the fibre end and the incident beam and to contamination of the fibre end. Such an arrangement where a lens is used to magnify an optical fibre end is often referred to as an 'expanded beam' arrangement.

[0006] Typically the end of the optical fibre and the lens are mounted in an elongate cylindrical tube that holds the lens and fibre in a fixed, particular positional relationship to each other. This helps to avoid losses due to misalignment between the lens and fibre in use. This assembly is usually known as a lens barrel or lens tube. The lens tube is often arranged so that an emerging beam has a particular alignment (e.g. is centred) with respect to a datum surface, such as the longitudinal outside surface, of the lens tube.

[0007] However, such an expanded beam arrangement has increased sensitivity to angular misalignment (i.e. relative tilt) between the optical axis of the fibre and the optical axis of the incident beam which is being coupled into the fibre, because any such misalignment results in the lens no longer focussing the incident beam exactly on the optical axis of the fibre. Rather, the focussed beam is displaced across the fibre end face, thereby leading to transmission losses. In an expanded beam arrangement such losses due to relative tilt between the optical axis of the fibre and the incident radiation beam are more significant than any losses due to lateral displacement between the optical axis of the fibre and the incident radiation beam. Therefore, even when using a lens tube, any coupling connector must ensure good angular alignment between the lens tube and incident light beam.

[0008] One way to achieve this is to have a connector having a throughbore which is sized to fit very snugly around the lens tube, such that the lens tube when inserted in the throughbore cannot tilt relative to the throughbore. By ensuring correct alignment of the connector throughbore with the incident radiation beam, tilt misalignment can be avoided. However, this arrangement requires precise and accurate construction of the connector, which can be difficult and expensive to achieve. Also, it can be difficult to insert the lens tube in the throughbore, because the necessarily tight fit means that any slight misalignment as the tube is inserted can result in the tube getting stuck in the bore. Also, any dirt or grit within the connector throughbore or on the lens tube will interfere with the fit and operation of the connector. This arrangement is not therefore really suitable for use in non-clean or more rugged environments.

[0009] Alternative methods of achieving good alignment rely on adjusting or manipulating the relative position of the fibre within the connector once it is inserted therein. However, such adjustment can in practice be difficult and require more complex connector constructions. In many situations one would like to be able to couple radiation into an optical fibre without the need to carry out any adjustments. For example, it is often necessary to repeatedly couple and decouple an optical fibre, such as when adjusting components or moving equipment. It is not desirable to have to adjust the position of the fibre within a connector each time it is to be used.

[0010] US-A-4146300 describes a prior art fibre optic connector. Claim 1 is characterised over this document. US-A-4215913, US-A-4296999 and DE-A-2602662 describe other prior art optical fibre connectors.

[0011] According to the present invention, there is provided an optical connector for coupling two optical fibre assemblies, comprising:

> a hollow body having a throughbore adapted to removably receive an optical fibre assembly at each end in use;
>
> a plurality of discrete engagement means located at circumferentially spaced apart positions within the hollow body throughbore; and
>
> one or more resilient biassing means engageable against the inserted optical fibre assemblies in use to bias radially and resiliently the assemblies against the engagement means and thereby against the hollow body;
>
> wherein the engagement means are such that they substantially do not deform when an optical fibre assembly is biassed against them; and characterised in that:
>
> > the engagement means are located at at least

three spaced intervals along the length of the throughbore and are arranged such that when two optical fibre assemblies are inserted in the connector, each inserted optical fibre assembly can be arranged to engage longitudinally and circumferentially spaced engagement means; and in that

the biassing means and engagement means are arranged such that the biassing means can be engaged against each inserted optical fibre assembly when so inserted in such a manner that each optical fibre assembly engages only a biassing means and engagement means and in such an arrangement is spaced apart from the inner surface of the hollow body throughbore and is held by the biassing and engagement means such that its longitudinal axis is substantially parallel to the longitudinal axis of the hollow body throughbore.

[0012] The connector of the present invention has a throughbore having discrete engagement means against which an inserted optical fibre assembly can be biassed in such a manner that the assembly only engages the body of the connector via the engagement means (and the biassing means). This means that an optical fibre assembly can always be arranged to engage the same parts of the connector (i.e. the engagement means) and thereby have its longitudinal axis in the same orientation within the throughbore, whenever it is inserted in the connector. An optical fibre assembly can thus be repeatedly relocated in the connector with its longitudinal axis in the same orientation, without the need for alignment adjustment after the assembly has been inserted in the connector. As noted above, this is important because tilt of an assembly within a connector can lead to transmission losses. There is also no need for the connector to receive the assembly tightly to ensure reliably repeatable orientation.

[0013] The connector of the present invention can further ensure that an inserted optical fibre assembly only engages the discrete engagement means and the biassing means and is held spaced from the main inner surface of the connector throughbore in use. This makes the connector less susceptible to degradation caused by dirt or contamination within the connector body or on the optical fibre assembly, and thus particularly suited for use in more rugged, non-clean environments.

[0014] For example, in this aspect of the present invention contamination could only be a problem if it occurred on the relatively small contact surfaces of the engagement means, biassing means and corresponding regions on the assembly (as compared to arrangements in which the assembly contacts a connector over substantially all of its outer surface, where any contamination will almost invariably be a problem). Also, any sliding between surfaces as an assembly is inserted will tend to clean the surfaces and push the dirt into the gap between the engagement means and throughbore inner surface. Furthermore, the relatively small contact areas between the assembly and connector in use means that there is a relatively high load at the contact points, which will tend to squeeze dust and dirt out from between the surfaces. Because the assembly is spaced from the throughbore surface, there is space for this dirt to move to where it will not interfere with the holding of the assembly, unlike in more tight fitting systems where any moved dirt will tend to cause a problem elsewhere.

[0015] The connector of the present invention is suitable for any sort of optical fibre assembly, such as the lens tubes or barrels discussed above, a tube or barrel mounting an optical fibre alone, a tube or barrel mounting an optical fibre and another optical component or element (such as a lens) (preferably in a fixed relationship), or even an optical fibre on its own.

[0016] The connector is adapted to receive an optical fibre assembly at each end, such that it can couple two optical fibre assemblies. The connector includess biassing means and engagement means, arranged to engage each assembly appropriately. Preferably there are two separate sets of biassing means and engagement means, one set for each optical fibre assembly, although this is not essential and the two assemblies can engage the same biassing means and engagement means, if desired.

[0017] The present invention is particularly suited as a connector for coupling two optical fibre assemblies which are prealigned so that the axis of their emerging light beam is parallel, e.g. centred, with respect to the outside longitudinal surface of the assembly, since by using identically arranged engagement and biassing means, parallel orientation of the optical axes of the assemblies can be ensured, without the need for careful adjustment of the positions of the assemblies in the connector.

[0018] This arrangement of the present invention is particularly advantageous because tilt between two optical fibre assemblies in the connector can be significantly reduced or even eliminated, simply by using uniform diameter engagement means and a uniform bore hollow body. The actual diameter of the engagement means or hollow body throughbore is not as critical, since relative linear displacement between the two optical fibre assemblies does not cause as significant losses as tilt misalignment. Uniformity is more easily achieved than absolute accuracy.

[0019] The engagement means can be any suitable means that' can provide discrete engagement surfaces for an optical fibre assembly with the connector throughbore and space the assembly from the throughbore inner surface. For example, they could comprise ridges or discrete studs extending radially from the throughbore inner surface towards the longitudinal axis of the throughbore. They could be integral with or permanently fixed to the throughbore inner surface, or separate, discrete components. In the latter case the arrangement should be such that in use when.an assembly is biassed against the engagement means, they themselves are then biassed against the hollow body appropriately. The engagement means substantially do not deform when an optical fibre assembly is biassed against them.

[0020] The engagement means are preferably adapted and arranged such that they engage an inserted optical fibre assembly and/or the throughbore (if appropriate) at discrete points, rather than over an extended region. This helps to ensure a reliably repeatable engagement. The engagement means could, for example, have spherical or hemispherical contact surfaces.

[0021] The engagement means preferably are arranged such that they will in use, space an inserted optical fibre assembly substantially uniformly from the throughbore inner surface along the entire length of the assembly. Thus, all the engagement means are preferably arranged such that they extend substantially the same distance radially towards the throughbore axis from the throughbore inner surface when an inserted assembly is biassed against them. They could for example all be of substantially equal diameter. This can help to ensure that the longitudinal axes of the throughbore and optical fibre assembly or assemblies are parallel.

[0022] Engagement means are located at spaced intervals along the length of the throughbore as well as at spaced intervals around the circumference of the throughbore, such that a properly inserted optical fibre assembly engages in use longitudinally and circumferentially spaced engagement means. This helps further to fix an inserted optical fibre assembly against tilt and movement in all directions and thus ensure consistency and repeatability of its orientation within the connector. Preferably the arrangement of engagement means is symmetrical about a plane containing the longitudinal axis of the hollow body, or symmetrical about a plane perpendicular to the longitudinal axis of the hollow body, or most preferably both. The engagement means should preferably generally be arranged towards one side of the throughbore, and generally opposed to the biassing means.

[0023] In a preferred embodiment, there are four engagement means arranged in two pairs spaced along the longitudinal axis of the throughbore, with the individual engagement means of each pair being located at the same longitudinal position in the throughbore but spaced from each other around the bore's circumference, for each optical fibre assembly. Thus there are preferably eight engagement means, arranged in circumferentially spaced pairs at four spaced apart locations along the longitudinal axis of the throughbore, i.e. two pairs for each assembly. The spacing of the engagement means should be such that a single optical fibre assembly can be arranged to lie beneath two longitudinally spaced pairs of engagement means simultaneously. Additional longitudinally spaced pairs can be provided, if desired.

[0024] The engagement means should be resistant to and preferably secured against longitudinal movement as an optical fibre assembly is inserted or removed. However, they are preferably free to rotate as an assembly is moved past them. Such rotation can make it easier to insert or remove an assembly. Furthermore, it allows different parts of the engagement means surface to engage an optical fibre assembly for any given insertion. Such rotation provides, in effect, a replenishable surface for engaging an assembly, and will tend to even out any wear of the engagement means surfaces since rotation of the engagement means will bring a new part of their surface into contact with the assembly. The rotation also means that insertion and removal of an assembly will tend to be self-cleaning as the surfaces slide against each other, thereby making the connector even more suited to use in rugged, non-clean environments.

[0025] The engagement means thus preferably comprise rotatable members, such as suitably mounted balls or rotatable rollers or cylinders.

[0026] The engagement means could be rotatably mounted or carried by the connector hollow body directly. However, in a particularly preferred embodiment the connector includes a hollow sleeve mounted coaxially within the connector body throughbore and adapted to receive the optical fibre assembly, which carries the engagement means in such a manner that they are free to rotate. The sleeve could, for example, include a plurality of holes located appropriately in it longitudinal surface, with an engagement means being located in each hole in such a manner that it is free to rotate. This is a particularly convenient way of making the engagement means rotatable. For example, where the engagement means are balls, they could be simply placed in the holes. Alternatively, the holes could be configured to support axles of, for example, rotatable rollers. The engagement means preferably should be sized and arranged such that they can protrude beyond each longitudinal surface of the sleeve simultaneously, as this enables them to engage the throughbore inner surface and the optical fibre assembly simultaneously, such that the assembly does not have to engage the connector body via contact with the sleeve. They are preferably free to float radially of the sleeve, at least a small distance.

[0027] The engagement means should preferably be arranged such that they are retained in the throughbore even when an optical fibre assembly is not inserted. This prevents the engagement means falling out of the connector when an assembly is not inserted. Thus, where a sleeve is used, the holes in the sleeve are preferably sized such that the engagement means can protrude into the sleeve bore through the holes, but cannot pass completely through the holes.

[0028] The biassing means can be any suitable means which can bias an inserted optical fibre assembly against the engagement means and thereby against the inner surface of the connector body throughbore. It could for example comprise a screw mounted in the hollow body which can be screwed into the throughbore to engage the optical fibre assembly. The biassing means could be arranged to apply its biassing force automatically whenever an optical fibre assembly is inserted, or such that the biassing force is selectively applicable by a user.

[0029] The force applied by the biassing means onto each engagement means in use is preferably substantially equal. The biassing means are preferably therefore arranged in generally opposed locations around the circumference of the throughbore to the engagement means. The arrangement of biassing means and engagement means is preferably symmetrical about a plane containing the longitudinal axis of the throughbore.

[0030] The biassing means does not have to act at substantially the same longitudinal position along the throughbore as each engagement means, but preferably does so, as this can help to avoid bending of the optical fibre assembly in use. There could, for example, be separate biassing means at each longitudinal position of an engagement means. However, preferably there is a single biassing means for each optical fibre assembly, but arranged such that it applies its biassing force at each longitudinal position of an engagement means that engages the assembly against which the biassing means acts in use. This helps to ensure that each engagement means engages an optical fibre assembly with the same force in use.

[0031] The biassing means could, for example, comprise an elongate plate or strip extending along the throughbore and movable towards and away from the longitudinal axis of the throughbore which has contact means mounted thereon for contacting the optical fibre assembly in use at the same longitudinal positions as the engagement means. Where two spaced-apart pairs of engagement means are used, there are preferably therefore two contact means spaced longitudinally along the plate at the same longitudinal spacing as the engagement means. Where a biassing force is applied to the plate, it is preferably done so equidistant from the contact means, again so as to help ensure equal contact forces in use.

[0032] The biassing means preferably engage an inserted optical fibre assembly at discrete points, rather than over an extended region, for the same reasons that the engagement means preferably do so. Thus it or they preferably include contact means adapted so as to engage an optical fibre assembly in point contact in use. The contact means could, for example, have spherical or hemispherical contact surfaces. The contact means could also be in the form of rotatable members, if desired.

[0033] The resilient biassing means resiliently bias an optical fibre assembly against the engagement means in use. The use of resilient biassing means allows the assembly to be inserted and removed without the need to positively adjust the position of the biassing means (since they can move resiliently to allow the assembly to be inserted or removed). The resilient biassing means could, for example, comprise a spring or springs or magnets arranged to act appropriately on an inserted optical fibre assembly.

[0034] A further advantage of resilient biassing means is that the biassing force applied to the optical fibre assembly can be more reliably and consistently applied, as compared to, for example, using a screw acting directly on the assembly to bias it against the engagement means. It is more difficult to reliably repeat the biassing force with a non-resilient biasing means. This can make it more difficult to repeat exactly the position of the assembly in the connector. Using non-resilient force also increases the risk of the applied force being too great, which could damage the assembly or connector and also reduce the repeatability of the connection.

[0035] Where a sleeve is mounted in the connector throughbore, it should of course, be appropriately arranged to accommodate the biassing means. It could, for example, have holes located in its circumference to allow the biassing means to enter the bore and engage an inserted optical fibre assembly.

[0036] The engagement means and biassing means contact surfaces are preferably made of hard materials so as to reduce wear in use.

[0037] It will be appreciated that repeated use of the connector of the present invention with a given optical fibre assembly, i.e. repeated removal and reinsertion of the assembly, (for which it is particularly suited) could mean that wear will tend to take place, and in the case where there are longitudinally spaced apart engagement means, wear will tend to be greater at the end of the optical fibre assembly which has to be pushed past both sets of engagement means in use as compared to the opposite end which only passes one set of engagement means as the assembly is inserted or removed. Such uneven wear could induce tilt, which, as noted above, is particularly undesirable in an expanded beam arrangement.

[0038] To avoid this problem of uneven wear, the biassing means are preferably arranged such that the biassing force is not applied except when the optical fibre assembly is adjacent all the engagement means which it is to engage in use; for example, where it is to engage only two longitudinally spaced sets of engagement means in use, when it is level with or adjacent the inner, second set of engagement means.

[0039] The biassing means could, for example, be arranged such that the biassing force is not applied until the optical fibre assembly is substantially fully inserted in the connector, or is inserted in the connector a predetermined distance, or such that the biassing force can be selectively applied by a user. With a resilient biassing means this latter arrangement could be achieved by, for example, providing actuating means which in its actuated state causes the resilient biassing means to engage an inserted optical fibre assembly, but which can be returned in an unactuated state to remove or not apply the resilient biassing force. For example, a manually actuable releasable pin could be provided which when pressed forces a resilient biassing means (e.g. spring) into a position in which it would engage an inserted optical fibre assembly. In this arrangement the connector is preferably provided with a locking means to maintain the biassing means in its actuated state, preferably in the form of a locking collar.

[0040] However, such a system requires extra action by a user to actuate the biassing means, and also requires access (whether directly or indirectly) by a user to the biassing means, which could make the connector construction more complicated and also more difficult to seal against the environment in which it is used (such that it may, for example, be more susceptible to dirt or water ingress).

[0041] Thus in a particularly preferred embodiment, the biassing means is arranged such that it does not apply a biassing force to an inserted optical fibre assembly until an inserted assembly overlaps all the pairs of engagement means that it is to engage in use, or is fully inserted, and then automatically applies the biassing force whenever the assembly overlaps all those engagement means. For example, where there are two longitudinally spaced pairs of engagement means for each optical fibre assembly, the biassing means is preferably arranged to apply its biassing force automatically once an inserted assembly overlaps both longitudinally spaced pairs of engagement means but not before. This arrangement is particularly suited for use with resilient biassing means, since it means that the biassing force is only applied once the optical fibre assembly has reached the last (e.g. second) pair of engagement means that it is to engage in use, such that ends of the optical fibre assembly experience equal load (and thus wear) as the assembly is moved past the engagement means as it is inserted or withdrawn. Thus any wear due to the insertion or removal of the assembly is now similar along the length of the assembly, and so the assembly is merely displaced, rather than tilted, by any such wear that does occur. As noted above, a linear displacement causes less losses than a tilt.

[0042] In this embodiment, the biassing means could, for example, extend longitudinally within the throughbore and be arranged within the throughbore such that it can pivot lengthwise (like a see-saw). This arrangement means that as an optical fibre assembly is inserted and engages the proximal end of the biassing means, the biassing means can pivot away such that no force is applied substantially until such time as the assembly engages the distal end of the biassing means, at which point the biassing means is pushed to pivot in the opposite direction thereby applying force to both ends of the assembly simultaneously.

[0043] The biassing means should preferably be of a configuration so as to help the pivoting action. It could, for example, comprise a substantially planar elongate strip supported on an appropriate pivot, preferably at the mid-point along its length. This arrangement of the biassing means is particularly suited to resilient biassing means which could, for example, comprise a longitudinally extending spring plate pivoted about its mid-point. Contact means to engage the optical fibre assembly can be provided at each longitudinal end of the biassing means, if desired, and be shaped and arranged so as to help the pivoting action. They could, for example, comprise hemispheres mounted on the surface of the biassing means.

[0044] The connector can include a locking means, such as locking collar, to retain an inserted optical fibre assembly in the connector. This locking means could also be used to lock the biassing means in its actuated position, if appropriate and desired. Stops can also be provided in the hollow body throughbore to prevent an optical fibre assembly being inserted past a particular point.

[0045] In a preferred embodiment of the present invention, the connector is arrangeable such that an optical fibre assembly can only be inserted in the connector in a particular orientation with respect to rotation about the longitudinal axis of the connector body throughbore. Such a fixed rotational alignment can be necessary and desired in some optical systems. An example of this would be where it is important to maintain polarisation of laser radiation, and polarisation maintaining optical fibres are being used. Another example is where plural fibres running side-by-side in an optical fibre assembly are to be aligned. Often there will only be one rotational orientation when all the fibres are correctly aligned with the optical component(s) to which they are to be coupled. By appropriate rotational fixing of the optical fibre assembly relative to the connector, the correct rotational alignment can be achieved and ensured.

[0046] One way to achieve this would, for example, be to indicate the rotational directions to be aligned on the optical fibre assembly and the connector such that they can be appropriately aligned in use. However, this arrangement is not necessarily desirable, since each time the optical fibre assembly was removed from the connector, it would be necessary to realign it upon reinsertion.

[0047] In a particularly preferred embodiment therefore, the connector further comprises a separable collar which mates in a fixed orientation with respect to rotation about the longitudinal axis of the connector throughbore with the connector body, which collar is securable to an optical fibre assembly in use.

[0048] In this arrangement the optical fibre assembly can be inserted in the connector and can then be rotationally aligned as desired, and then, while maintaining the rotational alignment between the collar and optical fibre assembly, the collar can be secured to the optical fibre assembly. The optical fibre assembly and the collar secured to it can then be subsequently removed and reinserted into the connector, with the assurance that the optical fibre assembly will be in the correct rotational orientation when the collar is correctly mated with the connector. This arrangement ensures that the optical fibre assembly can be removed and reinserted in the connector without loss of rotational alignment. Thus the optical fibre assembly can be removed from the connector and reinserted therein without the loss of polarisation alignment or the need for subsequent rotational alignment.

[0049] The collar can be secured to the optical fibre assembly by any suitable means, such as grub screws. It can be arranged to mate with the connector body in a predetermined rotational alignment by any suitable means, such as the connector body or collar including a pin which engages a slot or hole in the collar or connector body, respectively.

[0050] The collar can also be used to fix the position of the optical fibre assembly along the longitudinal axis of the connector throughbore, by securing it to the optical fibre assembly at an appropriate point along the length thereof.

[0051] A number of preferred embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows a side cross-sectional view of an optical fibre connector in accordance with a first embodiment of the present invention;
Figure 2 is a schematic cross-sectional view of the optical fibre connector of Figure 1;
Figure 3 shows a side cross-sectional view of an optical fibre connector in accordance with a second embodiment of the present invention;
Figure 4 is a schematic cross-sectional view of the optical fibre connector of Figure 3;
Figure 5 is a side cross-sectional view of the optical fibre connector of Figure 1 further comprising a collar for fixing the rotational orientation of the optical fibre assembly;
Figure 6 is a schematic end cross-sectional view of the connector of Figure 5;
Figure 7 is a side cross-sectional view of the optical fibre connector of Figure 3 further comprising a collar for fixing the rotational orientation of the optical fibre assembly; and
Figure 8 is a schematic end cross-sectional view of the connector of Figure 7.

[0052] The optical fibre connector of a first embodiment of the present invention comprises a hollow cylindrical body 2 having a throughbore 3 with an inner surface 4. A hollow sleeve or carrier 6 in the form of a cylindrical tube having a throughbore 8 fits snugly within the hollow body throughbore 3. The sleeve 6 can receive and releasably retain a pair of optical fibre assemblies 11 (one in each end) which are to be optically coupled to one another by means of the connector.

[0053] While the outer body, sleeve and optical fibre assemblies are shown as being in the form of cylindrical tubes, it should be appreciated that they can have other geometries, if desired.

[0054] The optical fibre assemblies 11 are shown in this embodiment as being lens tubes which carry an optical fibre and a lens. However, the optical fibre assembly is not restricted to such arrangements. It could, for example, comprise a cylinder mounting a different optical element and an optical fibre, a cylinder mounting an optical fibre alone, or simply the optical fibre on its own.

[0055] The sleeve 6 accommodates a plurality of discrete individual engagement means in the form of balls 10 in holes around its circumference. The arrangement is such that the balls 10 are positioned in circumferentially spaced pairs at spaced intervals along the longitudinal axis of the connector throughbore. Their longitudinal spacing is such that each optical fibre assembly engages two pairs of balls when properly inserted in the connector.

[0056] While the connector in this embodiment is shown as having a carrier accommodating eight balls, the connector is not restricted to accommodating this number of balls.

[0057] The balls 10 protrude through the holes in the sleeve into the throughbore 3. They are loosely held in place in the sleeve 6 such that they cannot move longitudinally along the sleeve, but are free to rotate as an optical fibre assembly moves past them and to float radially relative to the sleeve. The holes are sized such that the balls cannot fall out of the sleeve when the optical fibre assemblies are removed.

[0058] The diameters of all the balls 10 are substantially identical and the diameter of the throughbore 3 is uniform along its length. This helps to prevent relative tilt between the two inserted optical fibre assemblies. The actual diameters of the balls and the throughbore are not as critical, since, as noted above, the energy losses caused by tilt misalignment are greater than the energy losses caused by a linear displacement between the ends of the optical fibre assemblies. Uniformity is more easily attained than absolute accuracy.

[0059] The optical fibre assemblies 11 are biassed against the balls 10 and thereby against the inner surface of the connector body by resilient biassing means in the form of spring arrangements 14. Each spring arrangement 14 comprises an elongate resilient strip spring plate having two contact means in the form of hemispheres 16 on the surface that faces the optical fibre assembly in use. The sleeve 6 has appropriate holes in its circumference to allow the hemispheres to protrude through the sleeve.

[0060] The spring arrangements 14 include manual actuating means in the form of a pin 17 connected to the midpoint of the spring plate and extending outwardly through the wall of the connector body in a direction perpendicular to the longitudinal axis of the connector body.

[0061] Prior to the insertion of an optical fibre assembly into the connector, the spring arrangement 14 is in an unactuated state with the pin 17 in its outermost position. Once the assembly 11 has been fully inserted to its in use position, the pin 17 can be pressed inwardly to cause the spring arrangement 14 to exert a force on the assembly. The assembly is then biassed against the balls 10 which are in turn biassed against the inner surface 4 of the connector body 2.

[0062] To maintain the spring 14 in its actuated state, the connector is provided with a locking means in the form of a slidable locking collars 18. The cross-sectional shape of the collars matches that of the connector body and each collar is slidable along the connector between a position in which it covers a pin 17 to maintain the spring arrangement 14 in an actuated state and a position in which the pin 17 is exposed (and can therefore be returned by the resilient force of the spring plate to its unactuated position).

[0063] This arrangement enables an optical fibre assembly to be inserted into and removed from the connector without the biassing force being applied. In this way, substantial wear on an assembly as it is inserted or removed can be avoided.

[0064] The connector can also include a separable collar (not shown) which mates with the main body of the connector in a single orientation with respect to rotation about the longitudinal axis of the connector throughbore. To achieve this the collar can have a pin which engages in a corresponding slot on the connector body. The collar can further include means, such as a number of grub screws, to enable it to be secured to an optical fibre assembly. The collar allows the rotational orientation of an inserted optical fibre assembly with respect of the connector to be fixed. For example, the optical fibre assembly can be rotated about its longitudinal axis within the connector until the desired rotational orientation, such as when the polarisation axes are aligned, is achieved. Once this orientation has been achieved the collar can be secured to the optical fibre assembly, thereby ensuring correct rotational alignment of the optical fibre assembly relative to the connector when the collar is properly mated with the connector body thereafter.

[0065] In use, an optical fibre assembly would be inserted in each end of the connector, and once each assembly is properly inserted, the corresponding pin 17 depressed to bias the assembly against the balls 10 and thereby against the hollow body 2 of the connector. It should be noted that because of the spherical surfaces of the balls 10 and contact means 16, the engagement with the assembly is by point contacts, i.e. it is in accordance with the kinematic principle.

[0066] To remove the assemblies, the pins 17 are released to remove the biassing force, and the assemblies can then be readily removed.

[0067] During the insertion action, the outer surface of an optical fibre assembly will tend to slide against the surfaces of the balls and the biassing means contact surfaces. This sliding action will tend to clean the surfaces. The relatively high load at the point contact between the outer surface of the optical fibre assembly and the balls, and between the inner surface 4 of the outer tube 2 and the balls, will tend to squeeze any dust or dirt out from between the contacting surfaces, thereby again helping to prevent any detrimental effects due to contamination or dirt.

[0068] The balls accommodated in the carrier are also likely to rotate as an assembly is inserted or removed and therefore a new portion of each ball will be exposed to make contact with the optical fibre assembly. Thus the wear on each ball will tend to even out. This rotation also helps to ensure that clean surfaces are always in contact.

[0069] Figures 3 and 4 show a second embodiment of the present invention in which the biassing means is arranged in an alternative manner.

[0070] In this embodiment, instead of being actuated by pins pushed by a user, the spring arrangements 14 comprise elongate resilient strips 15 pivoted about their midpoints by pivots 20 which engage the inner surface 4 of the throughbore 3. In this arrangement, as an optical fibre assembly 10 is inserted into the carrier 6, the pivoting action of the spring prevents any force being applied by the spring on the assembly until a first 21 and second 22 end of the assembly are in contact with a distal 23 and proximal 24 end respectively of the spring.

[0071] As an assembly is inserted, when the first end 21 of the optical fibre assembly reaches the proximal end 24 of the spring arrangement 14, the assembly pushes the end 24 of the spring down and the distal end 23 moves up correspondingly as the spring plate pivots about pivot 20. As the optical fibre assembly is inserted further and its first end 21 makes contact with the distal end 24 of the spring arrangement, the first end 21 of the assembly pushes the distal end 23 of the spring down and the proximal end 24 of the spring moves up as the spring arrangement again pivots about pivot 20 in the opposite direction. Both ends of the spring arrangement are then in contact with the optical fibre assembly, such that a load is applied to the assembly to bias it against the balls 10. The pivoting action ensures that the same load is applied to the first and second ends of the assembly.

[0072] Since in this arrangement no force is applied to the optical fibre assembly until the first and second ends of the assembly are in contact with the proximal and distal ends respectively of the spring, both ends of the assembly wear at the same rate. Without such an arrangement, repeated insertion of the assembly 11 past permanently resilient engaging biassing means would cause the first end 21 of the assembly to wear more rapidly than the second end 22 because the second end only passes one set of balls 10 with each insertion whereas the first end passes two sets (in the embodiment shown). Such even wear of the assembly will only cause a uniform linear displacement of the optical fibre assembly, whereas if the wear of the first and second ends of the assembly was uneven, this could cause a tilt of the longitudinal axis of the assembly with respect to the central axis of the connector. As noted above, tilt causes greater radiation energy loss than a linear displacement.

[0073] Figures 5 and 6, and 7 and 8, show modifications to the first and second embodiments, respectively, to enable rotational orientation of the inserted optical fibre assembly to be fixed. In these arrangements collars 30 each having a pin 31 which engages with a corresponding slot 32 in the sleeve 6 are provided. The collars can be secured by means of grub screws 33 to the optical fibre assembly 11. The pin 31 and slot 32 arrangements mean that the collars 30 and sleeves 6 will only mate in a single rotational orientation. Thus by fixing the collar to the assembly 11, its rotational orientation upon insertion can be fixed and reliably repeated.

Claims

1. An optical connector for coupling two optical fibre assemblies (11), comprising:

    a hollow body (2) having a throughbore (3) adapted to removably receive an optical fibre assembly at each end in use;
    a plurality of discrete engagement means (10) located at circumferentially spaced apart positions within the hollow body throughbore; and
    one or more resilient biassing means (14) engageable against the inserted optical fibre assemblies in use to bias radially and resiliently the assemblies against the engagement means and thereby against the hollow body;

    wherein the engagement means are such that they substantially do not deform when an optical fibre assembly is biassed against them; and **characterised in that**:

    the engagement means are located at at least three spaced intervals along the length of the throughbore and are arranged such that when two optical fibre assemblies are inserted in the connector, each inserted optical fibre assembly can be arranged to engage longitudinally and circumferentially spaced engagement means; and **in that**
    the biassing means and engagement means are arranged such that the biassing means can be engaged against each inserted optical fibre assembly when so inserted in such a manner that each optical fibre assembly engages only a biassing means and engagement means and in such an arrangement is spaced apart from the inner surface of the hollow body throughbore and is held by the biassing and engagement means such that its longitudinal axis is substantially parallel to the longitudinal axis of the hollow body throughbore.

2. The connector of claim 1, wherein the engagement means (10) are arranged to rotate as an optical fibre assembly is moved past them.

3. The connector of claim 1 or 2, wherein the engagement means comprise rotatable members.

4. The connector of claim 2 or 3, wherein the connector includes a hollow sleeve (6) mounted coaxially within the connector body throughbore and adapted to receive the optical fibre assemblies, which sleeve carries the engagement means in such a manner that they are free to rotate.

5. The connector of claim 1, 2, 3 or 4, wherein there are eight discrete engagement means arranged in four pairs spaced along the longitudinal axis of the throughbore, with the individual engagement means of each pair being located at the same longitudinal position in the throughbore but spaced from each other around the throughbore's circumference.

6. The connector of any one of the preceding claims, wherein the engagement means are arranged such that they will in use space an inserted optical fibre assembly substantially uniformly from the throughbore inner surface along the entire length of the assembly.

7. The connector of any one of the preceding claims, wherein the biassing means (14) are arranged such that the force applied by the biassing means onto each engagement means in use is substantially equal.

8. The connector of any one of the preceding claims, wherein the biassing means can be selectively actuated to resiliently bias an optical fibre assembly against the engagement means in use.

9. The connector of any one of the preceding claims, wherein the biassing means is arranged such that it does not apply a biassing force to an inserted optical fibre assembly until the assembly has been inserted a predetermined distance into the connector, and then automatically applies the biassing force.

10. The connector of claim 9, wherein there are two longitudinally spaced pairs of engagement means for each optical fibre assembly to engage, and the or each biassing means is arranged to apply its biassing force automatically once an inserted assembly overlaps both longitudinally spaced pairs of engagement means but not before.

11. The connector of any one of the preceding claims, wherein the or each biassing means extends longitudinally within the connector body throughbore and is arranged within the throughbore such that it can pivot lengthwise as an optical fibre assembly is pushed past it in the throughbore.

12. The connector of claim 11, wherein the biassing means comprises a substantially planar elongate strip supported on a pivot at the mid-point along its length.

13. The connector of any one of the preceding claims, wherein the connector is arrangeable such that an optical fibre assembly can only be inserted in the connector in a particular orientation with respect to rotation about the longitudinal axis of the connector body throughbore.

14. The connector of claim 13, wherein the connector further comprises a separable collar (30) which mates in a fixed orientation with respect to rotation about the longitudinal axis of the connector throughbore with the connector body, which collar is securable to an optical fibre assembly in use.

15. The connector of any one of the preceding claims, wherein the connector includes two separate sets of biassing means and engagement means, one set for each optical fibre assembly.

16. The connector of any one of the preceding claims, further containing two optical fibre assemblies (11), each assembly comprising a cylindrical tube holding a lens and optical fibre in a fixed relationship.

Patentansprüche

1. Optischer Verbinder zum Koppeln zweier optischer Faserbaugruppen (11), der aufweist:

   einen Hohlkörper (2) mit einer Durchgangsbohrung (3), die dafür ausgelegt ist, beim Gebrauch eine optische Faserbaugruppe an jedem Ende entfernbar aufzunehmen,

   eine Vielzahl von diskreten Eingriffseinrichtungen (10), die sich an in Umfangsrichtung beabstandeten Positionen innerhalb der Durchgangsbohrung des Hohlkörpers befinden, und

   eine oder mehrere elastische Vorbelastungseinrichtungen (14), die beim Gebrauch gegen die eingeführten optischen Faserbaugruppen in Eingriff gebracht sind, um die Baugruppen radial und elastisch gegen die Eingriffseinrichtungen und dadurch gegen den Hohlkörper zu drücken,

   wobei die Eingriffseinrichtungen so ausgebildet sind, daß sie sich im wesentlichen nicht verformen, wenn eine optische Faserbaugruppe gegen sie gedrückt wird,

   dadurch gekennzeichnet, daß

   die Eingriffseinrichtungen in zumindest drei Abständen entlang der Durchgangsbohrung positioniert und so angeordnet sind, daß wenn zwei optische Faserbaugruppen in den Verbinder eingeführt werden, jede eingeführte optische Faserbaugruppe in in Längsrichtung und in Umfangsrichtung beabstandete Eingriffseinrichtungen eingreift, und daß die Vorbelastungseinrichtungen und die Eingriffseinrichtungen so angeordnet sind, daß die Vorbelastungseinrichtung gegen jede eingesetzte optische Faserbaugruppe in Eingriff gebracht werden kann, wenn diese so eingesetzt ist, daß jede optische Faserbaugruppe nur mit einer Vorbelastungseinrichtung und einer Eingriffseinrichtung in Eingriff gebracht ist und in einer solchen Anordnung von der inneren Oberfläche der Durchgangsbohrung des Hohlkörpers beabstandet und so von den Vorbelastungs- und den Eingriffseinrichtungen gehalten ist, daß ihre Längsachse im wesentlichen parallel zu der Längsachse der Durchgangsbohrung des Hohlkörpers verläuft.

2. Verbinder nach Anspruch 1, bei dem die Eingriffseinrichtungen (10) so angeordnet sind, daß sie sich drehen, wenn eine optische Faserbaugruppe an ihnen vorbeibewegt wird.

3. Verbinder nach Anspruch 1 oder 2, bei dem die Eingriffseinrichtungen drehbare Elemente aufweisen.

4. Verbinder nach Anspruch 2 oder 3, der eine hohle Hülse (6) aufweist, die koaxial in der Durchgangsbohrung des Verbinderkörpers angebracht und dafür eingerichtet ist, die optischen Faserbaugruppen aufzunehmen, wobei die Hülse die Eingriffseinrichtungen so trägt, daß sie sich frei drehen können.

5. Verbinder nach Anspruch 1, 2, 3 oder 4, bei dem es acht diskrete Eingriffseinrichtungen gibt, die in vier Paaren angeordnet sind, die entlang der Längsachse der Durchgangsbohrung beabstandet sind, wobei sich die einzelnen Eingriffseinrichtungen jedes Paars an der gleichen Längsposition in der Durchgangsbohrung befinden, jedoch um den Umfang der Durchgangsbohrung voneinander beabstandet sind.

6. Verbinder nach einem der vorstehenden Ansprüche, bei dem die Eingriffseinrichtungen so eingerichtet sind, daß sie beim Gebrauch eine eingeführte optische Faserbaugruppe entlang der gesamten

Länge der Baugruppe im wesentlichen gleichmäßig von der Innenfläche der Durchgangsbohrung beabstanden.

7. Verbinder nach einem der vorstehenden Ansprüche, bei dem die Vorbelastungseinrichtungen (14) so eingerichtet sind, daß sie beim Gebrauch im wesentlichen die gleiche Kraft auf jede der Eingriffseinrichtungen ausübt.

8. Verbinder nach einem der vorstehenden Ansprüche, bei dem die Vorbelastungseinrichtung selektiv betätigt werden kann, so daß sie beim Gebrauch eine optische Faserbaugruppe elastisch gegen die Eingriffseinrichtungen drückt.

9. Verbinder nach einem der vorstehenden Ansprüche, bei dem die Vorbelastungseinrichtung so eingerichtet ist, daß sie keine Vorbelastungskraft auf eine eingeführte optische Faserbaugruppe ausübt, bevor die Baugruppe eine vorbestimmte Strecke in den Verbinder eingeführt worden ist, und dann die Vorbelastungskraft automatisch ausübt.

10. Verbinder nach Anspruch 9, bei dem es zwei in Längsrichtung beabstandete Paare von Eingriffseinrichtungen für jede in Eingriff zu bringende optische Faserbaugruppe gibt und;bei dem die oder jede Vorbelastungseinrichtung so eingerichtet ist, daß sie ihre Vorbelastungskraft automatisch ausübt, sobald eine eingeführte Baugruppe beide in Längsrichtung beabstandeten Paare von Eingriffseinrichtungen überlappt, jedoch nicht vorher.

11. Verbinder nach einem der vorstehenden Ansprüche, bei dem die oder jede Vorbelastungseinrichtung in Längsrichtung innerhalb der Durchgangsbohrung des Verbinderkörpers verläuft und innerhalb der Durchgangsbohrung so eingerichtet ist, daß sie der Länge nach geschwenkt werden kann, wenn eine optische Faserbaugruppe in der Durchgangsbohrung an ihr vorbeigedrückt wird.

12. Verbinder nach Anspruch 11, bei dem die Vorbelastungseinrichtung einen im wesentlichen planaren, langgestreckten Streifen aufweist, der in Längsrichtung an einem Drehgelenk am Mittelpunkt getragen ist.

13. Verbinder nach einem der vorstehenden Ansprüche, bei dem der Verbinder so eingerichtet werden kann, daß eine optische Faserbaugruppe nur in einer bestimmten Orientierung in bezug auf eine Drehung um die Längsachse der Durchgangsbohrung des Verbinderkörpers in den Verbinder eingeführt werden kann.

14. Verbinder nach Anspruch 13, der weiter eine trennbare Einfassung (30) aufweist, die in einer festen Orientierung in bezug auf eine Drehung um die Längsachse der Durchgangsbohrung des Verbinders zu dem Verbinderkörper paßt, wobei die Einfassung beim Gebrauch an einer optischen Faserbaugruppe befestigt werden kann.

15. Verbinder nach einem der vorstehenden Ansprüche, der zwei getrennte Sätze von Vorbelastungs- und Eingriffseinrichtungen aufweist, wobei ein Satz für jede optische Faserbaugruppe vorgesehen ist.

16. Verbinder nach einem der vorstehenden Ansprüche, der weiter zwei optische Faserbaugruppen (11) aufweist, wobei jede Baugruppe ein zylindrisches Rohr aufweist, das eine Linse und eine optische Faser in einer festen Beziehung hält.

Revendications

1. Connecteur optique pour accoupler deux ensembles à fibre optique (11), comprenant :

   un corps creux (2) comportant un alésage traversant (3) apte à recevoir de façon amovible, en service, un ensemble à fibre optique à chaque extrémité ;
   une pluralité de moyens de prise discrets (10) situés en des positions espacées sur la circonférence, à l'intérieur de l'alésage traversant du corps creux ; et
   un ou plusieurs moyens de poussée élastiques (14) susceptibles de venir en prise, en service, contre les ensembles à fibre optique insérés pour pousser radialement et élastiquement les ensembles contre les moyens de prise et, ainsi, contre le corps creux ;

   dans lequel les moyens de prise sont tels qu'ils ne subissent essentiellement pas de déformation lorsqu'un ensemble à fibre optique est poussé contre eux ; et **caractérisé en ce que** :

   les moyens de prise sont situés à au moins trois intervalles espacés sur la longueur de l'alésage traversant et sont agencés de telle sorte que, lorsque les ensembles à fibre optique sont insérés dans le connecteur, chaque ensemble à fibre optique inséré puisse être agencé pour venir en prise avec des moyens de prise espacés de façon longitudinale et sur la circonférence ; et **en ce que**
   les moyens de poussée et les moyens de prise sont agencés de telle sorte que les moyens de poussée puissent venir en prise contre chaque ensemble à fibre optique inséré lorsque celui-ci est inséré de manière à venir en prise avec

un seul moyen de poussée et un seul moyen de prise et, dans un tel agencement, à être espacé de la surface interne de l'alésage traversant du corps creux et à être retenu par les moyens de poussée et de prise de façon à ce que son axe longitudinal soit essentiellement parallèle à l'axe longitudinal de l'alésage traversant du corps creux.

2. Connecteur selon la revendication 1, dans lequel les moyens de prise (10) sont agencés pour effectuer une rotation lorsqu'un ensemble à fibre optique passe devant eux.

3. Connecteur selon la revendication 1 ou 2, dans lequel les moyens de prise comprennent des éléments rotatifs.

4. Connecteur selon la revendication 2 ou 3, dans lequel le connecteur comporte un manchon creux (6) monté coaxialement à l'intérieur de l'alésage traversant du corps du connecteur et apte à recevoir les ensembles à fibre optique, lequel manchon porte les moyens de prise de manière à ce qu'ils soient libres en rotation.

5. Connecteur selon la revendication 1, 2, 3 ou 4, dans lequel il est prévu huit moyens de prise discrets agencés en quatre paires espacées le long de l'axe longitudinal de l'alésage traversant, les moyens de prise individuels de chaque paire étant situés à la même position longitudinale dans l'alésage traversant mais mutuellement espacés sur la circonférence de l'alésage traversant.

6. Connecteur selon l'une quelconque des revendications précédentes, dans lequel les moyens de prise sont agencés de façon à écarter, en service, un ensemble à fibre optique inséré sensiblement uniformément de la surface interne de l'alésage traversant sur la toute la longueur de l'ensemble.

7. Connecteur selon l'une quelconque des revendications précédentes, dans lequel les moyens de poussée (14) sont agencés de façon à ce que la force qu'ils exercent, en service, sur chaque moyen de prise soit sensiblement égale.

8. Connecteur selon l'une quelconque des revendications précédentes, dans lequel les moyens de poussée peuvent être actionnés de façon sélective pour pousser de façon élastique, en service, un ensemble à fibre optique contre les moyens de prise.

9. Connecteur selon l'une quelconque des revendications précédentes, dans lequel le moyen de poussée est agencé de façon à n'exercer une force de poussée sur un ensemble à fibre optique inséré que lorsque l'ensemble a été inséré jusqu'à une distance prédéterminée dans le connecteur, avant d'exercer automatiquement la force de poussée.

10. Connecteur selon la revendication 9, dans lequel il est prévu deux paires espacées longitudinalement de moyens de prise pour venir en prise avec chaque ensemble à fibre optique, et le ou chaque moyen de poussée est agencé pour exercer sa force de poussée automatiquement une fois, mais pas avant, qu'un ensemble inséré chevauche les deux paires espacées longitudinalement de moyens de prise.

11. Connecteur selon l'une quelconque des revendications précédentes, dans lequel le ou chaque moyen de poussée se prolonge longitudinalement à l'intérieur de l'alésage traversant du corps du connecteur et est agencé à l'intérieur de l'alésage traversant de façon à pouvoir pivoter dans le sens de la longueur lorsqu'un ensemble à fibre optique est poussé devant lui dans l'alésage traversant.

12. Connecteur selon la revendication 11, dans lequel le moyen de poussée comprend une bande allongée essentiellement plane supportée sur un pivot au milieu de sa longueur.

13. Connecteur selon l'une quelconque des revendications précédentes, le connecteur pouvant être agencé de telle sorte qu'un ensemble à fibre optique puisse uniquement y être inséré suivant une orientation particulière par rapport à une rotation autour de l'axe longitudinal de l'alésage traversant du corps du connecteur.

14. Connecteur selon la revendication 13, le connecteur comprenant en outre une bague séparable (30) qui s'accouple, suivant une orientation fixe par rapport à une rotation autour de l'axe longitudinal de l'alésage traversant du connecteur, avec le corps du connecteur, laquelle bague peut être, en service, assujettie sur un ensemble à fibre optique.

15. Connecteur selon l'une quelconque des revendications précédentes, le connecteur comportant deux groupes distincts de moyens de poussée et de moyens de prise, un groupe pour chaque ensemble à fibre optique.

16. Connecteur selon l'une quelconque des revendications précédentes, contenant en outre deux ensembles à fibre optique (11), chaque ensemble comprenant un tube cylindrique maintenant une lentille et une fibre optique dans une relation fixe.

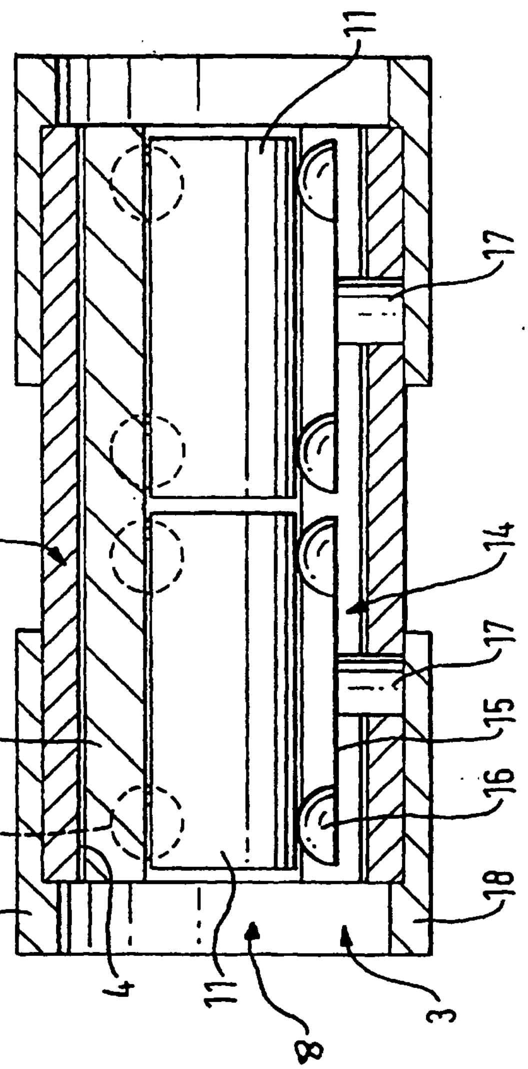

FIG. 1

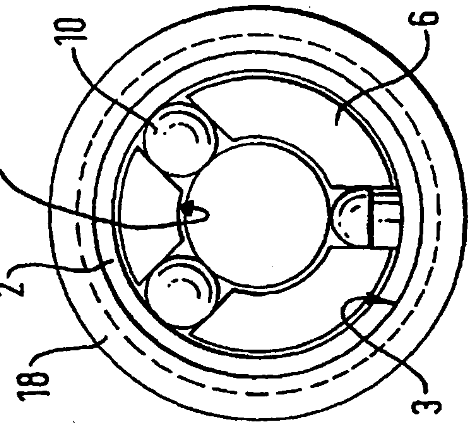

FIG. 2

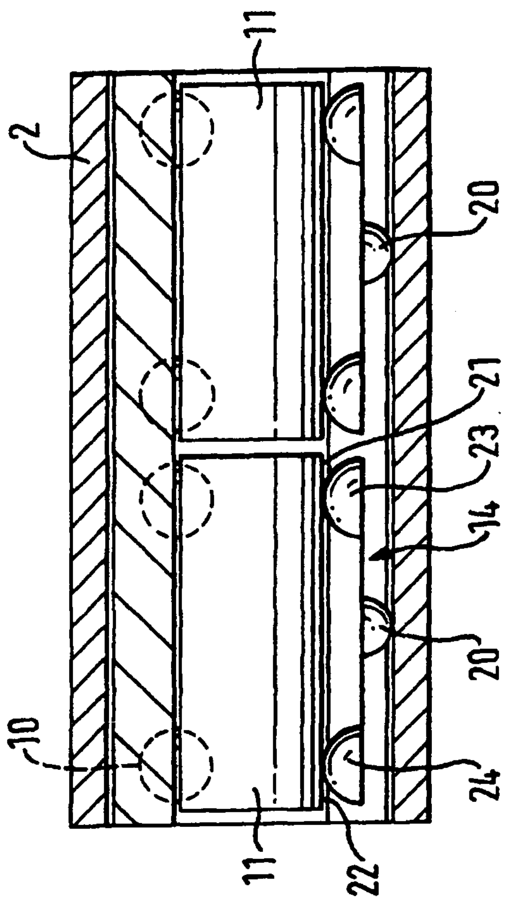

FIG. 3

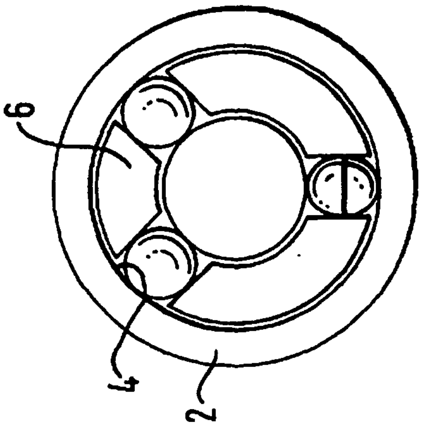

FIG. 4

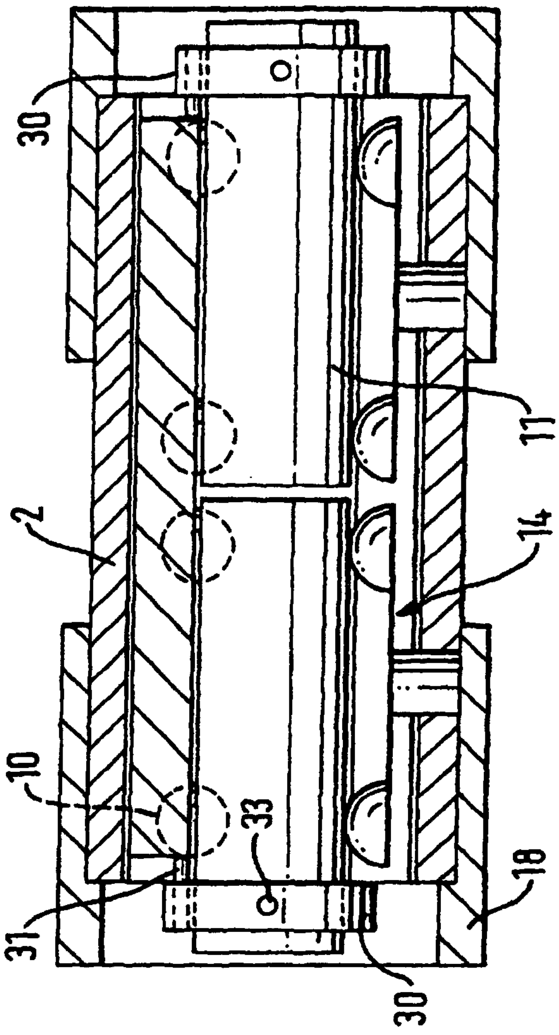

FIG. 5

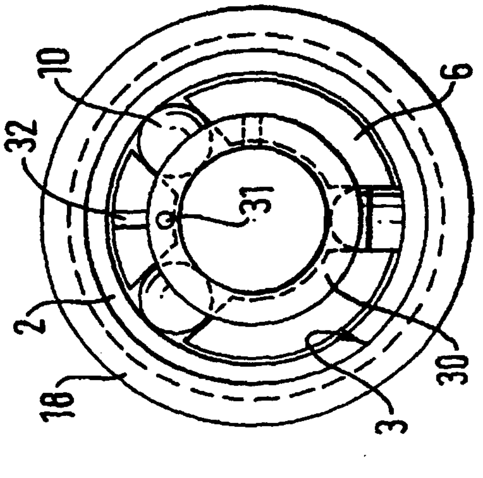

FIG. 6

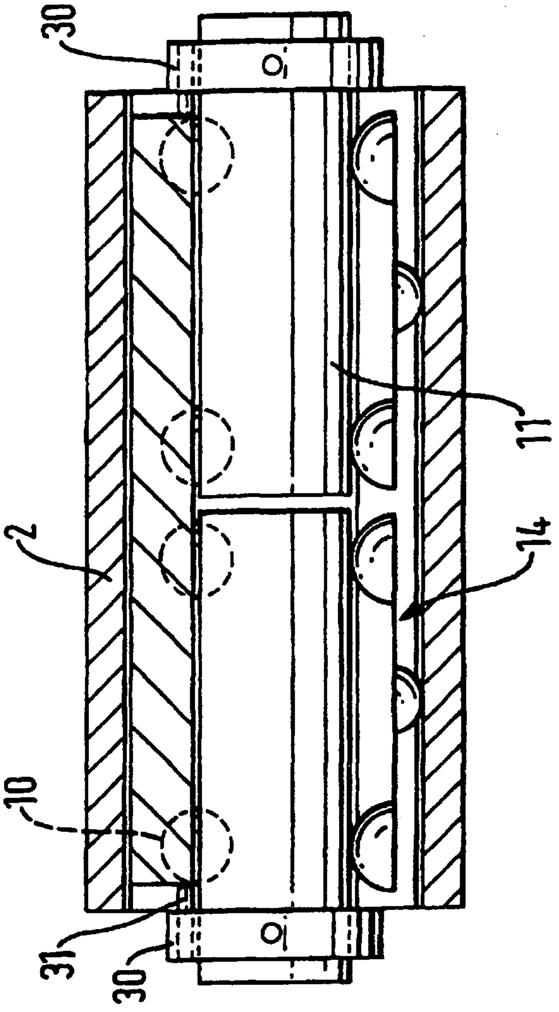

FIG. 7

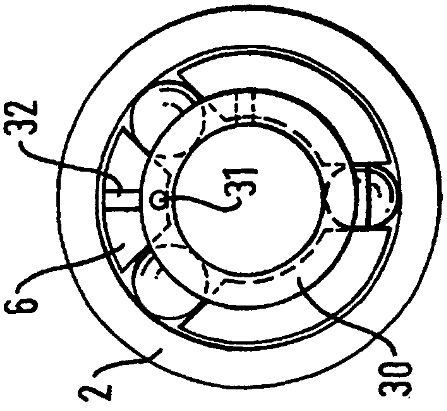

FIG. 8